DOPPLER ESTIMATES OF CARDIAC OUTPUT DURING PREGNANCY

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MOST physicians hesitate to subject a pregnant woman to the risk of invasive procedures because they know that the severity of her clinical problem will diminish with delivery of her child. Noninvasive methods of monitoring, therefore, offer some advantage for evaluation and management of high-risk obstetrical patients. We evaluated the use of suprasternal continuous-wave Doppler measurements of cardiac output in obstetrical patients. Although this method has been tested in surgical and intensive care patients, it has been seldom used in obstetrical patients. The study was done in three parts: the first part evaluated the stability of aortic root diameter in normal pregnant and nonpregnant volunteers, a measurement that is crucial to estimation of cardiac output by the Doppler method; the second part compared measurements of cardiac output in normal pregnant patients by the Doppler method with cardiac outputs from published studies obtained by traditional methods; and the third part consisted of measurements from several groups of high-risk patients.

MATERIALS AND METHODS

The protocol and consent form were approved by the institutional review board and informed consents were obtained from all patients. Aortic root diameters were measured using A-mode ultrasound at least twice during a six-month period at intervals of four to eight weeks in two groups of patients: nonpregnant controls (n = 10) and normal pregnant volunteers (n = 10). Measurements were obtained on the initial visit and later during a different trimester and/or postpartum. Cardiac output measurements were made with continuous wave Doppler ultrasound transducer incorporated in an UltraCom cardiac output monitor (Lawrence Medical Systems, Inc., Seattle, Washington). Measurements from pregnant patients were classified by week of gestation. For comparison, data from nonpregnant controls were divided into comparable intervals.

Cardiac output was also measured at intervals during pregnancy and, when possible, at six or more weeks after delivery in 20 normal volunteers. All measurements were made by the same clinician with the patients recumbent on their left side. Data for a given day are the arithmetic mean of three or more consecutive measurements. Since repeat measurements in patients were made during varying weeks of pregnancy, data were grouped by intervals of three weeks for analysis of change in time. Measurements of cardiac output were measured in an additional group of 14 pregnant patients with diagnoses of either chronic hypertension (n=10) or multiple gestation (n=4) who were followed in the high-risk clinic. Analysis of variance was used to evaluate changes related to time.

Results

Demographic data are summarized in Table I. Differences were observed between normal and high-risk patients in pregravid weight and weight at time of delivery. Analysis of variance showed no change in aortic root diameter over time in either nonpregnant control or pregnant patients (Table II). Conversely, cardiac output varied by stage of pregnancy and by patient, patient size contributing to the variation to some degree (Figure 1). To standardize measurements in pregnant patients, each cardiac output measurement during pregnancy was expressed as a percent of that patient's cardiac output measured six or more weeks after delivery and after resolution of peripartum change. Among normal pregnant patients, cardiac output peaked at about the 30th week of pregnancy, and was approximately 30% greater than their nonpregnant values. Afterward, these values tended to diminish.

Fewer data were obtained from the hypertensive patients during the early weeks of pregnancy, usually because they were not referred to the high-risk clinic until after the 24th week of pregnancy. In addition, these patients often delivered earlier, in some instances because labor was induced. As a group, these patients were less compliant and often missed scheduled clinic appointments. From 26 weeks, their pattern of change and both absolute and relative values resemble those of the normal controls. During the last weeks of pregnancy, however, cardiac output in the hypertensive group tended to be lower than in the normal pregnant controls.

Discussion

Questions about cardiac output often arise during the course of obstetrical care. Although considerable data exist for normal patients, information is scant and thus difficult to obtain for those with heart disease or with other

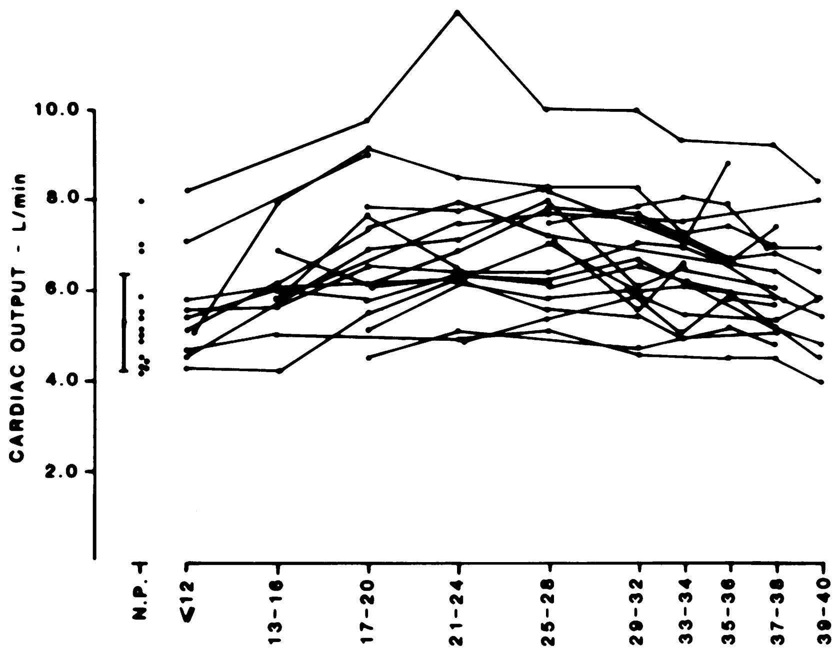
TABLE I. COMPARISON OF NONPREGNANT WOMEN AND CHRONICALLY HYPERTENSIVE OR NORMOTENSIVE WOMEN

	Nonpregnant controls (n=10)	*Normal, pregnant volunteers (n=20)*	*Chronically hypertensive, pregnant patients (n=10)*
Patient			
Age	32.4±3.6	30.4±3.7	26.9±5.6
Height (in)	64.9±2.2	64.6±2.7	65.1±3.3
Weight before pregnancy (lb)	129.4±15.9	123.3±2.0	173.9±40.5
Weight at delivery (lb)	—	157.2±20.0	208.6±37.8
Total weight gain (lb)	—	34.1±6.6	34.6±18.4
Time to delivery (wk)	—	39.3±1.4	37.8±2.1
Mean aortic root diameter (cm)	23.5±2.3	23.3±2.0	22.9±0.9
Infant Weight (gm)		3538.9±436.3	3257.3±558.9

TABLE II. COMPARISON OF AORTIC ROOT DIAMETERS BEFORE AND DURING PREGNANCY

	Before pregnancy (n=7)	*First trimester (n=5)*	*Second trimester (n=10)*	*Third trimester (n=8)*
Aortic root diameter (cm)	24.1	—	24.1	—
	20.6	—	20.6	—
	22.4	21.8	—	22.4
	22.4	22.4	—	23.5
	23.5	—	23.5	—
	22.9	—	22.9	—
	22.9	—	22.9	—
	—	27.1	27.1	—
	—	24.7	—	24.7
	—	21.8	—	20.6
	—	—	22.9	22.9
	—	—	20.6	20.6
	—	—	21.8	22.9
	—	—	28.2	28.2
Mean aortic root diameters (cm)	22.68±1.1	23.56±2.31	23.46±2.49	23.22±2.42

medical problems that put either the patient or her unborn child at risk. Risks inherent in right cardiac catheterization are a major obstacle. Hence, most physicians temporize such invasive procedures because the severity of a clinical situation, generally subsides upon delivery of the child. Cardiac output obtained by noninvasive Doppler techniques offers an excellent alternative



Comparison of changes in cardiac output (L/min) in study patients with normal pregnancies (n=20)

to traditional methods. However, before the method is used clinically, several points must be resolved. Foremost are questions of accuracy.

Ideally, the accuracy of the Doppler apparatus should be tested against traditional methods of measuring cardiac output, i.e., with dye or by thermodilution. In view of the constraints inherent in obtaining such data from pregnant women, we approached the problem another way. First, we tried to establish the stability of aortic root diameter. Estimates of cardiac output by the Doppler method are made from two measurements, aortic root diameter and velocity of blood flow. Of these measurements, the first is the most difficult and time-consuming, and requires the most technical skill. In circumstances in which repeat measurements may be required, as during clinical visits of an obstetrical patient, considerable time may be saved if root diameter is measured during an initial visit and then assumed to be constant during each subsequent examination. Considering the large changes in cardiac output, in blood volume, and in connective tissue that normally occur during pregnancy, it seems unreasonable to assume constancy without some confirmation. Data from the present study suggest that this assumption is correct. No systematic change of aortic root diameter was detected in obstetrical patients or in nonpregnant controls. Of equal importance, values of pregnant patients did not differ from those obtained from women in the general population. Thus, it would be reasonable to obtain and use estimates of aortic root diameter from a nomogram.

Current data verify the accuracy of Doppler measurements of cardiac output in pregnant patients. Both absolute values and their patterns of change during pregnancy conform to published data obtained with techniques well established in clinical literature (Figure 1).[1-4] Furthermore, the method also appears to be sensitive enough to detect differences between groups of normal and high-risk patients.

This study suggests two ways in which the Doppler method is valuable for determining cardiac output in pregnant patients. One is to follow the course of change in a high-risk obstetrical population, possibly to identify the onset of significant clinical problems. The second is to screen obstetrical patients and to identify those who might require and benefit from monitoring by more traditional, invasive methods.

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